Chapter

4

Site Design Measures

This Chapter explains how site design measures and low impact development (LID) can reduce the size of your project's stormwater treatment measures.

Site design measures for water quality protection are low impact development (LID) techniques employed in the design of a project site in order to reduce the project's impact on water quality and beneficial uses. Site design measures are not treatment measures. Including site design measures in a project does not meet the C.3 requirements for stormwater treatment, but it can help reduce the size of treatment measures (see Section 4.1). Site design measures can be grouped into two categories:

- Site design measures that ***preserve sensitive areas*** and high quality open space**,** and
- Site design measures that ***reduce impervious surfaces*** in a project.

This chapter emphasizes site design measures that reduce impervious surfaces, which can reduce the amount of stormwater runoff that will require treatment. This translates into smaller facilities to meet stormwater treatment requirements than would have been needed without the site design measures. Site design measures are also important in minimizing the size of any required hydromodification management measures for the site. A wide variety of site design measures can be incorporated in your project, including:

- Design ***self-treating*** areas and ***self-retaining*** areas.
- ***Reduce the size of impervious features*** in the project.
- Use cisterns or rain barrels to ***store rainwater*** onsite.
- Preserve and plant trees.

Where landscaped areas are designed to have a stormwater drainage function, they need to be carefully integrated with other landscaping features on the site early in project design. This may require coordinating separate designs prepared by different professionals.

> Site design measures used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures.

Remember that any site design measures (including self-treating areas) used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures. For this reason, your municipality may require you to include site design measures in the maintenance agreement or maintenance plan for stormwater treatment measures, or otherwise record them with the deed. Depending on the municipality, site design measures may be subject to periodic operation and maintenance inspections. Check with the municipal staff regarding the local requirements.

4.1 Using Self-Treating Areas

Some portions of your site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, landscaped areas (such as parks and lawns), green roofs, and areas paved with turf block. Areas of pervious pavement – such as porous concrete, porous asphalt, or unit block pavers – may function as self-treating areas if they are designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP. These areas are considered "self-treating" because infiltration and ***natural processes that occur in these areas remove pollutants*** from stormwater. Technical guidance for green roofs, pervious pavement, turf block, and permeable joint pavers is provided in Sections 6.9 through 6.11.

> If self-treating areas do not receive runoff from impervious areas, runoff from self-treating areas may discharge ***directly*** to the storm drain.

As long as the self-treating areas are not used to receive runoff from other impervious areas on the site, your drainage design may route the runoff from self-treating areas ***directly to the storm drain*** system or other receiving water. Thus, the stormwater from the self-treating areas is kept separate from the runoff from paved and roofed areas of the site, which requires treatment.

Even vegetated areas will generate some runoff. ***If runoff from a self-treating area co-mingles with the C.3.d amount of runoff from impervious surfaces***, then your stormwater treatment measure must be hydraulically sized to treat runoff from both the self-treating area and the impervious areas. This does not apply to the high flows of stormwater that are in excess of the C.3.d amount of runoff, because stormwater treatment measures are not designed to treat these high flows. If your project requires hydromodification management, then the runoff from self-treating areas will need to be included in the sizing calculations for HM treatment measures.

Figure 4-1 compares the size of the stormwater treatment measure that would be required to treat the runoff from a site, depending on whether or not the runoff from a self-treating area discharges directly to the storm drain system or other receiving water. In the first (upper) sequence, runoff from the self-treating area is directed to the stormwater treatment measure. In the second (lower) sequence, runoff from the self-treating area bypasses the treatment measure and flows directly to the storm drain system or other receiving water, resulting in a smaller volume of stormwater that will require treatment. This results in a ***smaller stormwater treatment measure***.

Figure 4-2 compares the conventional drainage approach to the self-treating area approach. The conventional approach combines stormwater runoff from landscaped areas with the runoff from impervious surfaces. Assuming the parking lot storm drain leads to a treatment measure, in the conventional approach, the treatment measure will need to be sized to treat runoff from the entire site. The ***self-treating area approach*** routes runoff from the landscaped areas directly to the storm drain system. In this approach, the treatment measure is sized to treat only the runoff from impervious areas.

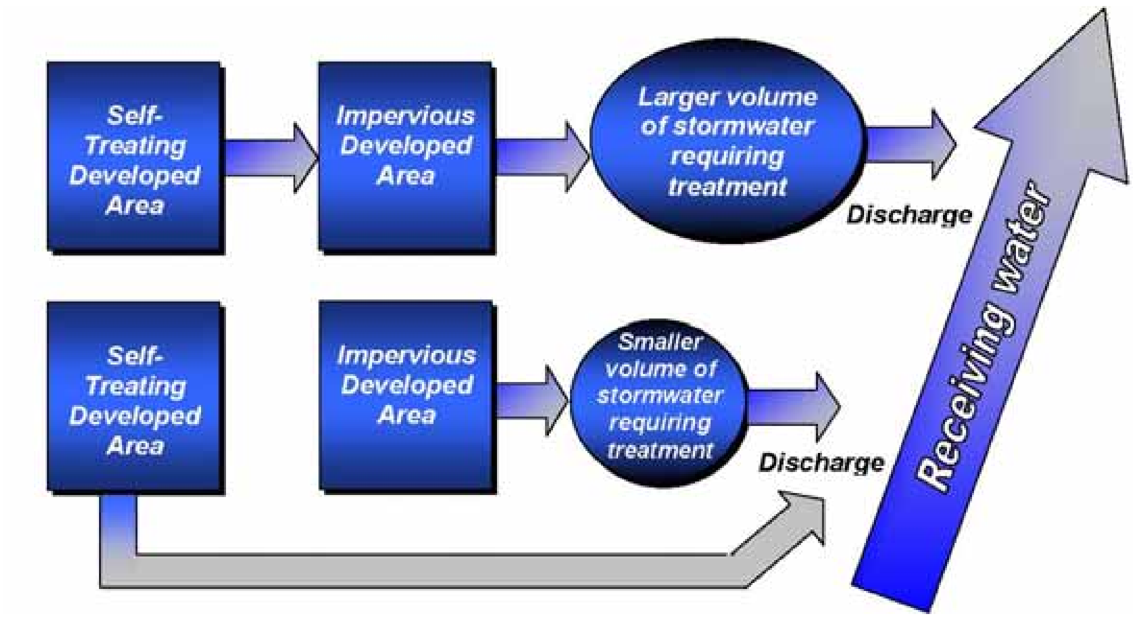
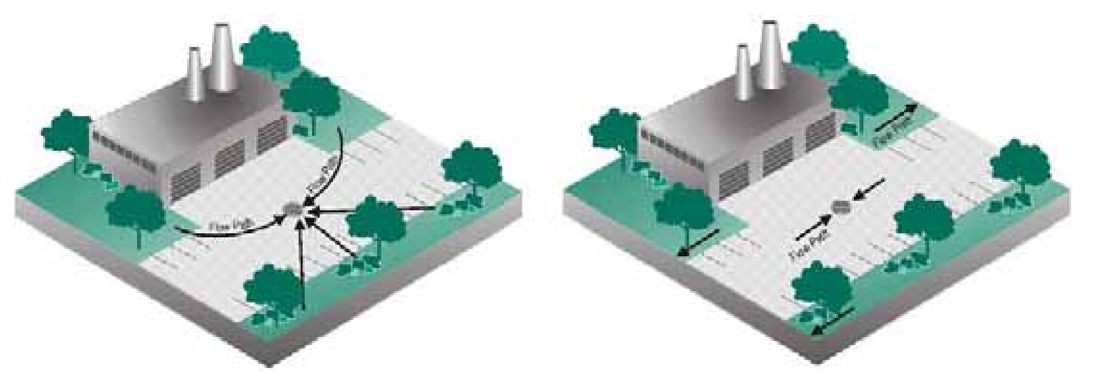


Figure 4-1: Self-Treating Area Usage (Source, BASMAA, 2003)



Conventional Drainage Approach **Self-Treating Area Approach**

Figure 4-2: Commercial/Industrial Site Compared to Same Site with Self-Treating Areas (Source, BASMAA 2003)

Figure 4-3 shows an example site in which the runoff from impervious areas must flow to the stormwater treatment measure before discharging to the storm drain, while runoff from the self-treating area may discharge directly to the storm drain. This is allowable because the self-treating area does not accept runoff from the impervious portions of the site.

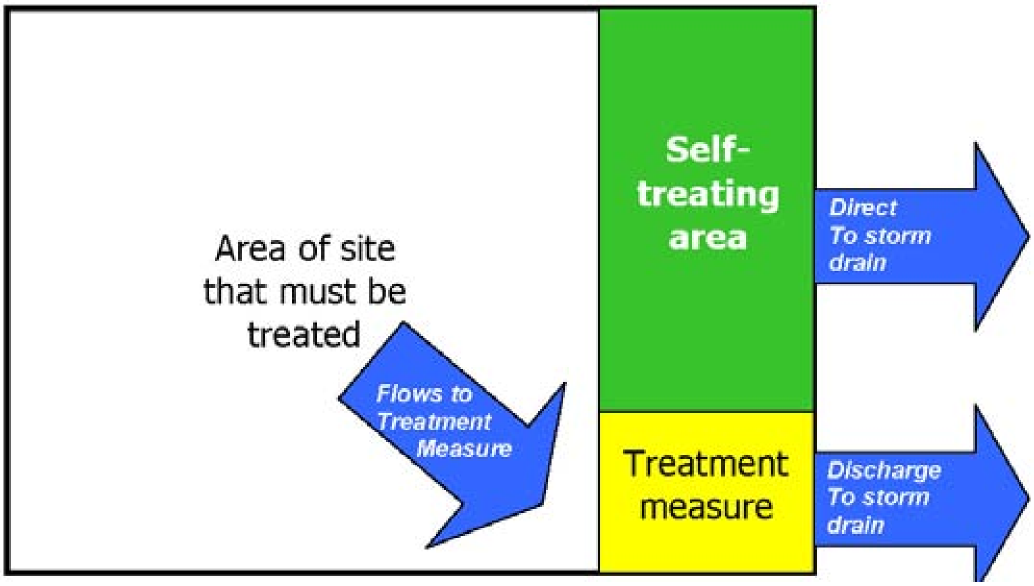


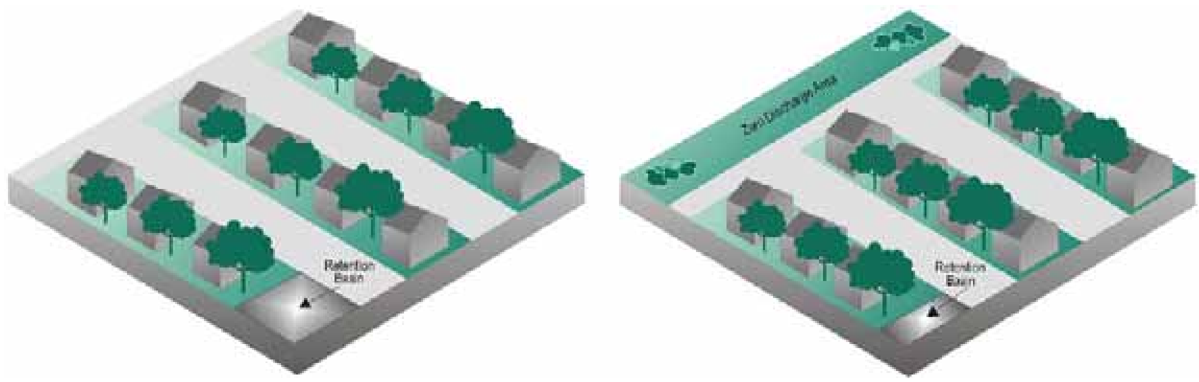
Figure 4-3: Schematic Drainage Plan for Site with a Self-Treating Area

4.2 Self-Retaining Areas

In “self-retaining areas” or “zero discharge areas,” a portion of the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas. If it is possible to create a self-retaining area on your site, you can design smaller stormwater treatment measures (as illustrated in Figures 4-4 and 4-5). ***Drainage from roofs and paving is directed to the self-retaining area***, where it can pond and infiltrate into the soil. Self-retaining areas may be created by designing concave landscaped areas at a lower elevation than surrounding paved areas, such as walkways, driveways, sidewalks and plazas. The following design considerations apply to self-retaining areas:

- Self-retaining areas are designed as concave landscaped areas that are bermed or ditched to retain the first one-inch of rainfall without producing any runoff.
- Runoff may enter the self-retaining area as sheet flow, or it may be piped from a roof or paved area. The elevation difference between the self-retaining area and adjacent areas should be sufficient to allow build-up of turf or mulch within the self-retaining area.
- A 2:1 ratio of impervious area to the receiving pervious area may be acceptable, if the soil can handle this amount of runoff without producing runoff.
- Drainage from self-retaining areas (for amounts of runoff greater than the first one-inch) must flow to off-site streets or storm drains without flowing onto paved areas within the site.

- If overflow drains or inlets to the storm drain system are installed within the self-retaining area, set them at an elevation of at least 3 inches above the low point to allow ponding. The overflow drain or storm drain inlet elevation should be high enough to allow ponding throughout the entire surface of the self-retaining area.
- Any pavement within the self-retaining area cannot exceed 5 percent of the total self-retaining area.
- Slopes may not exceed 4 percent.
- The municipality may require amended soils, vegetation and irrigation to maintain soil stability and permeability.
- Self-retaining areas shall be protected from construction traffic and compaction.



Conventional Design **Design with "Self-Retaining" or "Zero Discharge" Area**

Figure 4-4: Allowing some runoff from impervious surfaces to be retained and infiltrate in a "self-retaining" or "zero discharge" area can reduce the size of the required stormwater treatment measure. (Source: BASMAA 2003)

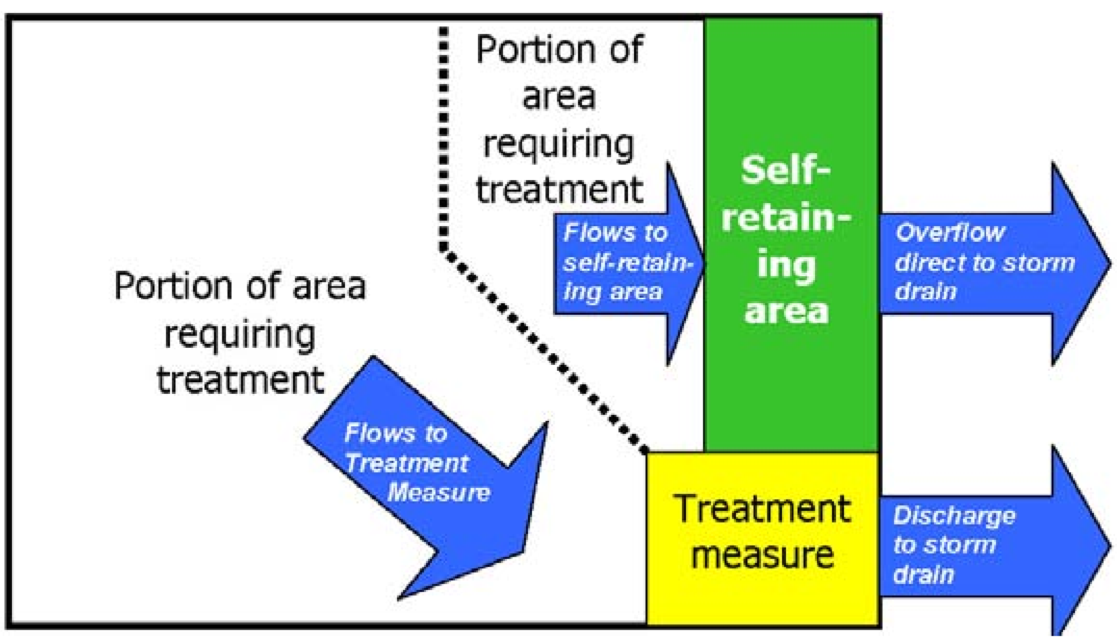


Figure 4-5: Schematic Drainage Plan for Site with a Self-Retaining Area

4.3 Reducing the Size of Impervious Areas

A variety of project features can be designed so that they result in a smaller "footprint" of impervious surface. These techniques generally need to be incorporated very early in the project design. A number of techniques for reducing impervious surfaces are described below.

Alternative Site Layout Techniques

Check with your local jurisdiction regarding its policies regarding the following site design measures:

- Use ***pervious pavement*** – such as porous concrete, porous asphalt, or unit block pavers – which are not considered "impervious" if designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP. See section 6.9 for pervious paving technical guidance.
- Reduce building footprints by using compact, ***multi-story structures,*** as allowed by local zoning regulations.
- ***Cluster buildings*** to reduce the length of streets and driveways, minimize land disturbance, and protect natural areas.
- *Design* ***narrow streets*** and driveways, as allowed by the local jurisdiction.
- *Use* ***sidewalks on only one side*** of the street may be appropriate in areas with little pedestrian and vehicular traffic, as allowed by the local jurisdiction.

Minimize Surface Parking Areas

A variety of techniques can be used to minimize surface parking areas, in terms of the number and size of parking spaces, as allowed by the local jurisdiction. These solutions focus on either reducing the demand for parking, maximizing the efficiency of parking utilization, or implementing design solutions to reduce the amount of impervious surface per parking space.

- Reduce parking demand by ***separating the cost of parking*** from the cost of housing or leasable space. This allows the buyer or tenant to choose how much parking they actually need and are willing to pay for.
- Maximize efficiency of parking utilization with ***shared parking*** that serves different land uses that have different times of peak demand. For example, an office use with demand peaks during the day can share parking with restaurants, where demand is greatest during the evening, and to some extent residential uses, where demand peaks are in the evenings, nights and on weekends.
- ***Structured parking*** can be an efficient way to reduce the amount of impervious surface needed for parking. Structured parking can be integrated with usable space in buildings that also house office or residential space, or include ground-floor retail lining the street. Shared parking strategies can work very well with structured parking.

- ***Parking lifts*** are another way to reduce the amount of impervious surface needed for parking. A parking lift stacks two to three cars using a mechanical lift for each surface space. They can be operated manually by residents or employees, or by a valet or parking attendant. With proper training for residents, employers, or parking attendants, this strategy can be a practical way to double or triple the parking capacity given a set amount of land.

Figure 4-6: Parking Lifts in Parking Garage, Berkeley

- Another way to maximize the efficient use of parking area is ***valet parking***, where attendants park cars much closer and tighter in than individual drivers would in the same amount of parking space.

4.4 Rainwater Harvesting and Use

Water storage systems ***collect rainwater from roofs*** and other impervious building surfaces, and store it so it may be released soon after a storm, or used for irrigation and other non-potable uses.

Water storage systems in proximity to the building may be subject to approval by the building official. The use of waterproofing as defined in the building code may be required for some systems, and the municipality may require periodic inspection. Check with municipal staff for the local jurisdiction's requirements.

Rainwater storage systems connect to a building's gutters and downspouts and convey the water to storage vessels, such as ***rain barrels*** or above- or below-ground ***cisterns***. In "metered detention and discharge," the collected stormwater is slowly released into the landscape beds in the hours following the storm, at a rate that allows for better filtration and is less taxing to the community storm drain. As allowed by the local jurisdiction, harvested rainwater may be used for toilet flushing, car washing, washing machines, and chlorinated swimming pools. For rainwater to serve as useful irrigation in the Bay Area, it may need to be stored until the dry season, requiring more storage capacity.

Water storage systems should include ***preventive measures for pollutants and mosquito control***. The initial rainfall of any storm often picks up the most pollutants from dust, bird droppings and other particles that accumulate on the roof surface between rain events. ***If rainwater is used for drip irrigation*** a roof washer device may be needed to separate the dirtier, early rainfall (which is likely to contain solids that could clog the drip system) and divert it so that it does not mix with the cleaner runoff that follows. Through a simple valve design, a roof washer diverts the first 0.02 inches of rainfall per 24-hour period per square foot of roof area away from the rainwater harvesting storage tanks or cisterns. Water diverted by a roof washer may be routed to a landscaped area large enough to accommodate the volume, or a hydraulically-sized treatment measure. Roof washers should be installed in such a way that they will be easily accessible for regular maintenance. Also, water storage facilities must be equipped with covers with tight seals, to reduce mosquito-breeding risk.


Figure 4-7: Rainwater is collected and used for flushing toilets at Mills College, Oakland.

Although many types of roofing materials may contribute pollutants to harvested water, ***certain roofing materials have particular concerns***. Water harvested from roofs with wood shingles or shakes may be suitable for irrigating ornamental landscaping only, due to the leaching of compounds. In addition, food-producing gardens should not be watered with rainwater from roofs with asphalt shingles, tar, lead, or other materials that may adversely affect food for human consumption. Indoor use of rainwater harvested from roofs with copper flashing may discolor porcelain. The quantity of rainwater that can be collected from a roof is in part a function of the roof texture. Smoother surfaces will yield more water.

Meeting Stormwater Treatment Requirements with Harvesting and Use

If rainwater harvesting systems are used to meet the MRP stormwater treatment requirements, they must be designed to handle back-to-back storms. In the event that the cistern or other water storage unit were full when a storm occurred, in order to meet stormwater treatment objectives, any water released from the cistern would need to be treated before discharging to storm drain system. To avoid the redundancy of installing both a rainwater harvesting system and biotreatment measures that could treat overflows from the system, rainwater harvesting systems intended to meet stormwater treatment requirements should ***achieve one of the following three objectives:***

- ***Use the full C.3.d amount of stormwater runoff for irrigation.*** In order to capture and use the full C.3.d amount of runoff for irrigation use, the following conditions must be met (a) there must be sufficient irrigation demand for the full annual amount in or near the project, and (b) it must be feasible to store the amount of the rainwater that is harvested during the wet season (October through April) until it is used for irrigation (primarily May through September, although some irrigation may occur during wet season months).
- ***Use the full C.3.d amount of stormwater for non-irrigation purposes.*** In order to capture and use the full amount of runoff for non-irrigation uses, the following conditions must be met: (a) there must be a reliable non-potable demand to use the water supply during the rainy season, and (b) the cistern or other water storage unit must be designed with sufficient volume to accommodate consecutive storms without discharging any of the C.3.d amount of stormwater to the storm drain system.

- ***Use the full C.3.d amount of stormwater from only a portion of the site.*** It may be possible to divide your site into drainage areas and store and use rainwater from only one drainage area, such as a rooftop or portion of a rooftop. As in the first two scenarios, the full C.3.d amount of runoff would need to be used for either irrigation or non-irrigation purposes, but in this case it would be the full C.3.d amount of runoff from only the specified drainage area of the site, which would allow for a smaller cistern. The C.3.d amount of stormwater runoff from the rest of the site would need to be treated with other stormwater treatment measures.

Regional criteria and procedures for determining the feasibility and infeasibility of meeting stormwater treatment requirements with rainwater harvesting and use, infiltration, and evapotranspiration will be submitted to the Water Board by May 1, 2011. The criteria and procedures will subsequently be included in Appendix J.

4.5 Tree Preservation and Planting

Trees perform a variety of functions that reduce runoff volumes and improve water quality. Leaf canopies intercept and hold rainwater on the leaf surface, preventing it from reaching the ground and becoming runoff. Root systems create voids in the soil that facilitate infiltration. Trees also absorb and transpire large quantities of groundwater, making the soil less saturated, which allows more stormwater to infiltrate. Through the absorption process, trees remove pollutants from stormwater and stabilize them. Finally, tree canopies shade and cool paved areas.

The following characteristics will determine how effectively a tree performs the functions described above:

- Persistent foliage
- Canopy spread
- Longevity
- Growth rate
- Drought tolerance
- Tolerance to saturated soils
- Resistance to urban pollutants (both air and water borne)
- Tolerance to poor soils
- Root pattern and depth
- Bark texture
- Foliage texture
- Branching texture
- Canopy density

Soil volume, density, and compost, along with appropriate irrigation the first three years, are important to tree performance. Other aspects that influence how street trees perform include resistance to exposure (wind and heat) and resistance to disease and pest infestations.

When planting trees, particularly along streets where space is limited and roots may damage hard surfaces, ***consider the use of***

Structural soils may allow the installation of ***large shade trees*** in narrow medians where the tree otherwise may conflict with infrastructure.

structural soils. Structural soil is a planting medium that consists of a stone skeleton structure for strength and clay soil for water retention, which allows urban trees to grow under pavement. The structural soil system creates a load-bearing matrix with voids filled with soil and air, essential for tree health. This allows for greater tree growth, better overall heath of trees, and reduced pavement uplifting by tree roots. The voids that benefit the tree roots also provide increased stormwater storage capacity, allowing tree pits in paved areas to serve as a series of small detention basins. See www.hort.cornell.edu/uhi/outreach/csc/ for more information on structural soils. Before including structural soils in your project, please contact the municipality for information and requirements specific to the local jurisdiction.

Load-bearing modular grid products, such as the Silva Cell, have also been developed to allow the planting of trees in uncompacted native soils, fill soils, or stormwater treatment soils, extending under sidewalks and other areas of pavement. With the Silva Cell product, for example, each cell is composed of a frame (or frames) and a deck (see Figure 4-8).

Figure 4-8: Silva Cells, stacked three units high. (Source: Deep Root Technologies, www.deeproot.com). The use of this photograph is for general information only, and is not an endorsement of this or any other proprietary product.

The frames can be stacked one, two, or three units high before they are topped with a deck to create a maximum amount of soil volume for tree root growth and stormwater infiltration. Cells can be installed laterally as wide as necessary. Void space within the cells may accommodate the surrounding utilities.